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THE EFFECT OF SUPPLEMENTING NAPIER GRASS OR MAIZE STOVER BASAL DIET WITH EITHER GLIRICIDIA, CLITORIA OR MUCUNA ON MANURE QUANTITY AND QUALITY IN JERSEY COWS

[EFECTO DE SUPLEMENTAR UNA DIETA BASAL DE PASTO NAPIER O RASTROJO DE MAÍZ CON GLIRICIDIA, CLITORIA O MUCUNA SOBRE LA CANTIDAD Y CALIDAD DE LA EXCRETA DE VACAS JERSEY]

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SUMMARY

The effect of manure and legumes on crop production has been widely studied and the positive effects documented. However, hardly any information is available on the effect of feeding legumes on the quantity and quality of manure. A feeding trial was therefore carried out to evaluate the effect of Napier grass or maize stover basal diet supplemented with three legumes (Clitoria, Gliricidia and Mucuna) on the quantity and quality of manure produced by Jersey cows. The relationship between manure production and feed intake or live weight of the animal was also determined. The basal diet or legume fed had no effect on the amount of faeces produced or as a proportion of its live weight. However, when faeces were expressed as a proportion of total dry matter intake, cows fed on maize stover produced more (P<0.05) faeces (46.6%) than those fed on Napier grass (40.5%). Legume supplementation did not affect the quantity of manure produced but increased (P<0.05) the amount of N in faeces by 44% and 78% for cows fed Mucuna and Gliricidia respectively. Legume supplementation reduced (P<0.05) the amount of P, K and tannins in the faeces. Cows fed on Napier grass based diets produced faeces with higher (P<0.05) levels of P, and lower levels of Mg, than those fed on maize stover based diets. The two basal diets however had no significant effect on the amount of C, K and tannins in the faeces. It is concluded that manure output is about 1.2% of an animals' live weight and 40-50% of the total dry matter intake. Nitrogen in faeces is increased by supplementing cows fed low quality forages with legume forage.

Key words: Mucuna, Gliricidia, Clitoria, Napier grass, Maize stover, manure quantity and quality, cattle

RESUMEN

Los efectos positivos de las excretas y leguminosas en la producción de cultivos han sido ampliamente estudiado. Sin embargo existe poca información sobre el efecto de alimentar rumiantes con leguminosas sobre la cantidad y calidad de la excreta. Se efectuó una prueba de alimentación para evaluar el efecto de suplementar una dieta basal de pasto Napier o rastrojo de maíz con tres leguminosas (Clitoria, Gliricidia y Mucuna) sobre la calidad de la excreta producida por vacas Jersey. Se determinó la relación entre producción de excreta y consumo de alimento o peso vivo del animal. La dieta basal o la leguminosa ofrecida no tuvieron efecto sobre la cantidad de heces producida. Sin embargo, expresado como proporción del consumo total de material seca, las vacas alimentadas con rastrojo produjeron más heces (P<0.05) (46.6%) que las alimentadas con pasto Napier (40.5%). La suplementación con leguminosas no afecto la cantidad de excreta producida pero incrementó la cantidad de N en las heces en 44 y 78% en vacas alimentadas con Mucuna y Gliricidia respectivamente. La suplementación con leguminosa redujó (P<0.05) la cantidad de P, K y taninos en las heces. Las vacas alimentadas con Napier produjeron heces con mayores niveles de P (P<0.05) y menor contenido de Mg. Las dos dietas basales no tuvieron efecto sobre la cantidad de C, K y taninos en las heces. Se concluye que la excresión de excretas es *c.* 1.2% de peso vivo y 40-50% del total de material seca consumida. En dietas basadas en forrajes de baja calidad el nitrógeno en heces se incrementa suplementando con leguminosas.

Palabras clave: Mucuna, Gliricidia, Clitoria, pasto Napier, rastrojo de maíz, bovinos, cantidad y calidad excreta.

INTRODUCTION

Animal manure is a very important source of nutrients for crops. Farmers in coastal Kenya practice mixed farming, where some type of livestock is found in almost every farm. Use of livestock manure to fertilize the soil is an important linkage between livestock and soil fertility improvement (Nyambati, *et al*, 2003). Lekasi *et al.* (2001) also noted that the small mixed farm featuring a dairy enterprise has a significant nutrient supply available for use to improve soil fertility. Research work at KARI Mtwapa showed that cattle slurry increased maize grain and stover yield (Mureithi *et al.*, 1996). Studies at the centre and on-farm have also shown increased grain yield on manure application (Saha and Muli, 2000). In a survey in the Kenyan highlands, Harris *et al.* (1997), gained the impression from farmers that inorganic fertilizer is used for feeding the plants to give a short-term response whereas manure feeds the soil for long-term sustainability (Lekasi *et al.,* 1998). The use of manure in the coastal lowlands is however minimal. Farmers believe that manure burns the seed and others have not seen the benefits of manure application because they use smaller quantities than recommended or they do not give it enough time for mineralization. Although studies have been carried out to determine the effects of manure application on grain yield, hardly any information is available on the effects of livestock feeding on the quantity and quality of manure produced. Such information will help farmers determine how much manure to expect from their animals and how much to apply to meet the crops' nutrient requirements. The objectives of this study were to determine the effect of feed quality on manure quality and quantity and to relate manure production to feed intake and liveweight of the animal.

MATERIALS AND METHODS

Site

The study was carried out at Kenya Agricultural Research Institute, Mtwapa (KARI Mtwapa), which is located in the Coast Province of Kenya. The site lies at 3^o 50'S, 39^o 44'E, at an altitude of 15 metres above the sea level. The Centre is in coastal lowland agro ecological zone three (CL3) also referred to as the coconut-cassava zone. It has an annual rainfall of 1200mm distributed into a long rainy season in April - July and the short rains in October to December. The mean monthly minimum and maximum temperatures are 22 and 30^oC respectively. The relative humidity is high (over 80%) (Jaetzold and Schmidt, 1983). The site has well-drained sandy soils, which are prone to leaching and have low levels of organic matter (0.66% C) and nitrogen (0.03-0.7%N) according to MoA (1988). Natural pastures in the area are dominated by star grass (C*ynodon dactylon*) and *Panicum* species while the main herbaceous species are commelina (*Commelina benghalensis)* and various broad weed species. The farming system is dominated by mixed farming where cattle, sheep, goats and poultry are found in almost every farm, alongside tree crops mainly dominated by coconut and cashew. Intensive Dairy cattle production has been promoted with improved forage production practices under zero grazing (Muinga *et al*., 1992).

Feeds

Napier grass (*Pennisetum purpureum* Schumach) established in 1989 within Gliricidia *(Gliricidia sepium* Jacq) alleys, was cut back at a height of 10 cm from the ground after the onset of long rains. Calcium ammonium nitrate (CAN) was applied at 5 g per stool equivalent to 60 kg N per hectare per year to facilitate fast re-growth. Similarly Gliricidia was cut back to allow for re-growth. Clitoria *(Clitoria ternatea* L) and Mucuna *(Mucuna pruriens*) were established in pure stand at the onset of the long rains. Total rainfall during the two-month experimental period was 120 mm and supported reasonable forage re-growth. The maize stover was obtained from a Pwani hybrid 4 (PH4) maize crop at the centre. Maize bran and mineral licks used in the experiment were purchased in bulk from a local supplier.

Experimental animals

Twenty-four Jersey cows with an average age and live weight of 7.2 (range 2.5-10.5) years and 262.3 (range 225-345) kg, respectively, were selected from a dairy herd grazing natural pastures at KARI Mtwapa. They were in mid lactation with an average daily milk yield of 5.0 kg (range 3.7 to 7.5 kg per day).The animals were weighed and divided into eight groups of three, balanced for body weight. They were housed in well-ventilated stalls with individual feeding facilities. Weekly weights were taken thereafter. They were also sprayed with a di-amidide acaricide weekly against external parasites. All the animals were dewormed with an antihelminitic drench before the start of the experiment. Blood samples were taken every week from the jugular vein, to screen for East Coast fever (ECf) and trypanosomosis.

Treatment diets

The basal diet was made up of Napier grass or maize stover plus 3 kg of maize bran and 70 g of a mineral lick daily. Each of the two basal diets was supplemented with no legume, Clitoria, Mucuna or Gliricidia to make a total of 8 treatments. Each treatment was replicated three times.

Experimental procedure and design

Four weeks re-growth of Napier grass was manually harvested daily by cutting at a height of 10 cm from the ground. The stored maize stover and freshly harvested Napier grass were mechanically chopped to pieces of about 40 mm length before feeding to the animals. Mucuna and Clitoria were harvested at 10 cm from the ground after attaining 50% flowering at two and a half months of age. They were chopped manually to pieces of about 20 mm before feeding to the animals. Leaves and tender twigs of approximately 5 mm diameter were separated from Gliricidia branches and fed to the animals. The forages were chopped to reduce selection by the animal and enhance intake. Weighed amounts of the basal diets were offered in the morning and added in the afternoon to ensure availability at all times. The respective legumes (8 kg Clitoria, Gliricidia or Mucuna), maize bran (3 kg) and mineral lick 70 g) were offered in two equal amounts in the morning and afternoon daily. Feeds and feaces were sampled weekly, bulked for the whole period per feed and a sub-sample taken for nutrient analysis and dry matter determination. The treatments were arranged in a split plot design to evaluate the effect of the basal diet (main plot: Napier grass vs. maize stover) and legume supplementation (sub-plots: none, Mucuna, Clitoria and Gliricidia).

Data collection

The animals were subjected to a 7-day adaptation period in which they were fed their respective treatment diets. Experimental data was collected for 7 weeks. Feed refusals were weighed every morning (0600hrs) and recorded before fresh feed was offered. Animals were weighed every week and weights recorded. Total daily faecal output per animal was collected by an attendant as it was dropped and bulked in individual buckets before weighing and recording. Lactation performance data has been reported elsewhere by Juma (2006).

Sample analysis

Forage and faecal samples were subjected to proximate analysis to determine their chemical composition. Dry matter (DM), ash and nitrogen (N) content were measured according to AOAC (1990). Total P, K and carbon were determined according to the methods described by Okalebo *et al.*, (2002). The procedure of Van Soest *et al.*, (1991) was used to determine neutral detergent fibre (NDF).

Statistical analysis

The effect of the two basal diets, supplementation and their interaction were determined by analysis of variance (ANOVA) using the SAS general linear model procedure (SAS, 1987) and means separated by computing the least significant difference (LSD) at $P<0.05$.

RESULTS AND DISCUSSION

During the experimental period, the minimum and maximum temperatures ranged between 20 to 23^{o}C and 27 to 30^{o}C respectively. The interactions between the basal diets and the legumes were not statistically significant and therefore only the main effects of the basal diet and legume are reported.

Chemical composition of the feeds

Maize stover was more fibrous than Napier grass as shown by the higher NDF (Table 1). The N level in Napier grass was higher than that in maize stover. The N in maize stover was however higher than 0.5% reported earlier at the same site by Abdulrazak *et al.* (1996 and 1997) and 0.8% by Muinga *et al.* (2002). The legumes had higher N and lower fibre than the stover and Napier grass. Gliricidia tended to have higher N (3.7%) compared to Clitoria (3.5%) and Mucuna (2.9%). Muinga, *et al.* (2002) reported similar values (Gliricidia 4.2, Clitoria 3.4 and Mucuna 3.4%). The NDF was higher in Clitoria and Mucuna than in Gliricidia which had higher N. This indicated that Gliricidia was of higher quality than the two other legumes. The tannin level was however higher in Gliricidia than in Mucuna and Clitoria. The samples were not replicated and statistical analyses were not carried out to verify these differences.

Effect of basal diets on feed intake

By the second week of the experiment, the cows consumed all the 8 kg legume offered which, was expected to provide 2 kg DM. However, differences in DM intake were noted due to differences in the DM content of the legumes and the amount consumed by each cow was 2.0, 2.1 and 1.7 kg for Clitoria, Gliricidia and Mucuna, respectively (Table 2). The cows consumed more ($P<0.05$) Napier grass than maize stover (4.5 vs. 2.7 kg). The total DM intake was also higher ($P<0.05$) for the animals that were fed Napier grass than those fed maize stover (8.5 vs. 6.7kg). This could have been due to the lower fibre in Napier grass (69%) compared to maize stover (78%), which would mean higher digestibility of the Napier grass based diets. Low fibre and high N reduces retention time of ingesta in the reticulo-rumen thereby creating space in the rumen for more feed intake. Cows fed Napier grass based diet had higher ($P<0.05$) N intake than those fed maize stover.

Table 1. Nutrient composition of the feeds on DM basis.

	Maize bran	Stover	Napier	Clitoria	Gliricidia	Mucuna
	………………………………… (%) …………………………………					
Ash	7.80	6.40	8.80	8.70	8.90	10.10
Organic matter	92.20	93.60	91.20	91.30	91.10	89.90
Nitrogen	2.16	0.83	1.20	3.50	3.70	2.90
NDF	78.30	78.40	69.00	60.50	50.60	59.60
Calcium	0.01	0.20	0.12	0.15	0.40	0.63
Phosphorous	0.06	0.02	0.01	0.03	0.02	0.04
Carbon	43.13	40.58	36.74	38.02	43.77	42.49
Potassium	0.39	1.05	1.51	0.44	0.85	1.07
Magnesium	0.13	0.15	0.10	0.13	0.16	0.18
Tannins	0.30	1.08	1.27	1.71	2.23	0.30

DM=dry matter, NDF=neutral detergent fibre

Table 2. Basal diet and legume effects on daily DM and N intake.

	DM intake (kg)				N intake
	Maize bran	Basal diet	Legume	Total	(g)
Legume					
None	2.6	4.3^{a}	0.0^{d}	6.9^{c}	101.6^{d}
Clitoria	2.6	3.3^{b}	2.0^{b}	7.9^{ab}	158.7^{b}
Gliricidia	2.6	3.5^{b}	2.1^{a}	8.2^{a}	172.1^{a}
Mucuna	2.6	3.1^{b}	1.7^{c}	7.4^{bc}	138.0^{c}
LSD (P=0.05)		0.74	0.09	0.80	9.01
Basal diet					
Napier grass	2.6	4.5^{a}	1.5^{a}	8.5^{a}	157.2^{a}
Maize stover	2.6	2.7^{b}	1.4^{a}	6.7^{b}	128.0^{b}
LSD (P=0.05)		1.30	0.22	1.03	6.37

Means in a column bearing the same superscript(s) within legume and within basal diet are not significantly different (P>0.05)

Effect of legume supplementation on feed intake

Basal diet intake was depressed significantly (P<0.05) by legume supplementation (Table 2). This could be due to substitution effect of the more fibrous basal diet with an easily digested legume. However, total DM intake was significantly (P<0.05) higher in cows supplemented with Gliricidia (8.2 kg) and Clitoria (7.9 kg) than for those fed on the basal diet only (6.9kg). This may have been due to the basal diet intake which tended to be higher for cows fed Gliricidia (3.5 kg) and Clitoria (3.3 kg) than those fed Mucuna (3.1) and also the significantly higher Gliricidia and Clitoria intake. On the other hand, Gliricidia and Clitoria had higher N than Mucuna and may have enhanced digestibility in the rumen (Table 1). Nitrogen intake was enhanced by legume supplementation. Mean daily N intake significantly (P<0.05) increased from 102 to 138, 159 and 172 g for cows fed none or supplemented with Mucuna, Clitoria or Gliricidia respectively.

Effect of basal diet on manure quantity

The daily faecal output was 3.4 and 3.1 kg for cows fed Napier grass or maize stover respectively (Table 3). These values were not significantly different even when expressed as a proportion (1.3 vs. 1.2%) of body weight. The results were similar to earlier results from the same site where cows fed maize stover, or Napier grass based diets produced 3.7 vs. 3.4 kg equivalent to 1.3 vs. 1.4% of the live weight respectively (Muinga *et al.*, 2002). The figures were also within the range (1.0 to 1.8%) reported by Lekasi *et al.*, (2001) for steers fed on Napier grass and supplemented with either a commercial concentrate or poultry waste. Steers on high concentrate supplementation had higher faecal output. The basal diets had a significant effect (P<0.05) on faecal output expressed as a percentage of total dry matter intake (TDMI) where cows fed on a stover based diet had a higher percentage than those on Napier grass (46.6 vs. 40.5%). Muinga *et al.*, (2002) reported similar findings although the values (53.9 vs.

41%) were relatively higher; this can be explained by the high intake of the Napier grass based diets and similar faecal output irrespective of the basal diet. These results however contrast with Kirchgessner and Kreuzer (1986) who observed that dung production and dry matter content of faeces increased with dry matter intake.

Effect of legume supplementation on manure quantity

Legume supplementation had no significant effect on daily faecal output which ranged from 3.1 to 3.5 kg, (Table 3). This was similar to the results of an earlier study at the same site by Muinga *et al. (*2002) who reported values ranging from 3 to 4 kg. Faecal output expressed as a percentage of body weight was not significantly affected by legume supplementation and ranged from 1.2 to 1.3 %. These were similar to values reported earlier (between 1.0 to 1.6%) by Muinga *et al.* (2002). This translates to about 4.5 kg DM of manure daily for a 400 kg cow. This is in agreement with a report (Nyambati *et al.*, 2003) from Western Kenya which showed that one cow could produce about 4 kg DM of manure per day. Faecal output expressed as a percent of TDMI was lower (P>0.05) for cows supplemented with Clitoria (42.1%) than for cows given no legume supplement (46.4%). The legume supplements had similar effect on faecal output expressed as a percent of TDMI (ranging from 42.1 to 42.9%). Similar results were reported in an earlier study (Muinga *et al.,* 2002) at the same site.

Manure quality

Legume supplementation significantly (P<0.05) increased N concentration in the faeces by 56 and 78 % for cows fed Mucuna and Clitoria respectively (Table 4). This agrees with Lekasi *et al.,* (2001), who reported that there exists a linear relationship between N intake and the N excreted both in faeces and in the urine. He found that total N excreted ranged between 36 and 58% of the total N intake and concluded that as the N concentration increases in the diet so does the faecal N excreted. In the current study the N proportion in the faeces in relation to N intake ranged from 24 to 38%. Legume supplementation significantly reduced K, P and tannin levels while NDF and Carbon were not affected by legume supplementation (Table 4). Nitrogen, P and K are the major nutrients considered in fertilizers and legume supplementation would seem to have an antagonistic effect where N increases while P and K decrease. There was no significant difference between faecal N from cows fed either of the two basal diets (Table 4). This was in agreement with earlier reports at the same site by Muinga *et al.*, (2002), who concluded that except for K, treatment diets had no significant effect on the nutrient composition of the faeces. However in the current study, N output in the faeces was significantly (P<0.05) higher in the stover based diets (Table 3). The reason could be that high fibre diets result in significantly higher undigested dietary N in faeces. High fibre diets may encourage enhanced rumen microbial activities culminating in rich faecal N excretion of bacterial origin (Lekasi, *et al.*, 2001). Carbon, K, NDF and tannins were not affected by type of basal diet. Phosphorous levels were significantly (P<0.05) higher while Mg was significantly lower in faeces from Napier grass based diets than in maize stover based diets (Table 4). The current study and that reported by Lekasi *et al.*, (2001) suggest that high N diets lead to production of high N in the faeces which would enhance productivity of low N soils like those of coastal lowland Kenya.

Table 3. The effect of basal diet and legume supplement on daily faecal DM and N intake.

Legume	Live weight (kg)	DM output			N output (g)
		DM (kg)	% of live weight	% of total DM intake	
None	275[a]	3.1 [a]	1.2 [a]	46.4 [a]	29.8c
Clitoria	268[a]	3.3 [a]	1.2 [a]	42.1 [b]	34.7[bc]
Gliricidia	266[a]	3.5 [a]	1.3 [a]	42.9 [ab]	55.4[a]
Mucuna	256[a]	3.1 [a]	1.2 [a]	42.8 [ab]	42.3[b]
LSD (P=0.05)	45.0	0.49	0.13	3.84	10.86
Basal diet					
Napier grass	270[a]	3.4 [a]	1.3 [a]	40.5[b]	37.3[b]
Maize stover	263[a]	3.1 [a]	1.2 [a]	46.6 [a]	43.8[a]
LSD (P=0.05)	30.9	0.0.90	0.34	13.2	4.03

Means in a column bearing the same superscript(s) within legume and within basal diet are not significantly different (P>0.05)

Table 4. Effects of different legumes and basal diets on nutrient composition of faeces and N output.

	C	N	P	K	Mg	NDF	Tannins
Legume	…………………………………...……… (%) ………………..........……………………						
None	39.1[a]	0.9[c]	0.40[a]	0.63[a]	0.47[ab]	77.4[a]	0.86[a]
Clitoria	39.5[a]	1.1[bc]	0.26[b]	0.40[b]	0.65[ab]	78.2[a]	0.65[b]
Gliricidia	40.4[a]	1.6[a]	0.22[b]	0.41[b]	0.50[a]	78.7[a]	0.60[b]
Mucuna	38.6[a]	1.3[ab]	0.22[b]	0.43[b]	0.43[b]	79.0[a]	0.50[b]
LSD	5.63	0.32	0.081	0.130	0.229	3.63	0.165
Basal diets							
Napier grass	40.3[a]	1.1[a]	0.37[a]	0.51[a]	0.39[b]	79.2[a]	0.64[a]
Maize stover	38.6[a]	1.4[a]	0.19[b]	0.43[a]	0.64[a]	77.4[a]	0.66[a]
LSD	4.79	0.38	0.133	0.116	0.131	4.606	0.169

Means in a column bearing the same superscript(s) within legume and within basal diet are not significantly different (P>0.05)

CONCLUSIONS

From this experiment it can be concluded that legume supplementation does not significantly affect the quantity of manure produced by the animal. Similarly, the quality of the basal diet does not significantly affect the amount of manure produced. Faecal output is about 1.2% of an animals live weight and 40 to 50% of its total dry matter intake. The N in the faeces of cows from the current study ranged from 1 to 1.6% of DM. These figures can be used to estimate the amount of manure expected from a dairy farm for use either in forage or crop production. From the figures in this study, a 400 kg cow could produce about 4.8 kg faecal DM daily, equivalent to 1752 kg faecal DM per annum. At 1% N this would contain 17.5 kg of N. The recommended application rate of N for maize is 60 kg N ha^{-1}. This could be produced by 3.5 cows or 3 cows and a heifer, which can be sustained in a hectare of Napier grass grown in Gliricidia or Leucaena alleys.

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